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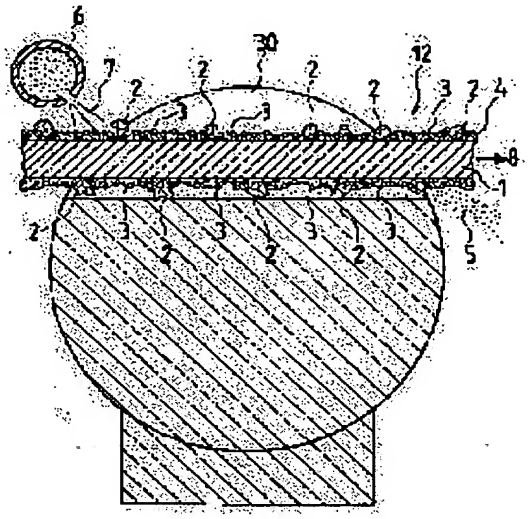
(54) WIRE WITH FIXED ABRASIVE GRAINS AND CUTTING METHOD FOR FIXED ABRASIVE GRAINS WIRE SAW

(57)Abstract:
PROBLEM TO BE SOLVED: To obtain a favorable wafer cut surface and also machine efficiently at a low cost, in the cutting by the wire with fixed abrasive grains.
SOLUTION: In this cutting method, the wire with fixed abrasive grains, in which the abrasive grains having a plural different grain size are mixed and stuck and/or the abrasive grains constituted by the material quality of plural different kinds are mixed and stuck on the wire 12 with fixed abrasive grains used to a fixed whetstone grains wire saw, is used. Thereby, the life of the wire with the fixed abrasive grains can be extended while maintaining the cut surface accuracy of an ingot 30 in a favorable state and a production efficiency is improved and a production cost can be reduced.



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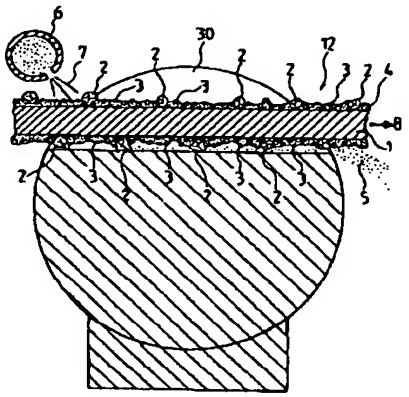
(54)【発明の名称】固定砥粒付ワイヤ及び固定砥粒ワイヤソーの切断方法

(57)【要約】

【課題】固定砥粒付ワイヤによる切断加工において、良好なウェーハ切断面を得るとともに、能率良く低コストで加工する。

【解決手段】固定砥粒ワイヤソーに用いる固定砥粒付ワイヤ１２に、複数の異なった粒度を持つ砥粒が混在して固着されている、且つ／又は、複数の異なった種類の材質で構成された砥粒が混在して固着されている固定砥粒付ワイヤを用いたので、インゴット３０の切断面精度を良好な状態に維持しつつ固定砥粒付ワイヤの寿命を延ばすことができ、且つ、生産能率の向上及び生産コストの低減を図ることができる。



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【特許請求の範囲】

【請求項１】　ワイヤ表面に砥粒が固着された固定砥粒付ワイヤを走行させながら被加工物を押し当てることにより、該被加工物を切断する固定砥粒付ワイヤにおいて、

前記固定砥粒付ワイヤは、複数の異なった粒度を持つ砥粒が混在して固着されていることを特徴とする固定砥粒付ワイヤ。

【請求項２】　ワイヤ表面に砥粒が固着された固定砥粒付ワイヤを走行させながら被加工物を押し当てることにより、該被加工物を切断する固定砥粒付ワイヤにおいて、

前記固定砥粒付ワイヤは、複数の異なった種類の材質で構成された砥粒が混在して固着されていることを特徴とする固定砥粒付ワイヤ。

【請求項３】　ワイヤ表面に砥粒が固着された固定砥粒付ワイヤを走行させながら被加工物を押し当てることにより、該被加工物を切断する固定砥粒付ワイヤにおいて、

前記固定砥粒付ワイヤは、複数の異なった粒度と、複数の異なった種類の材質とで構成された砥粒が混在して固着されていることを特徴とする固定砥粒付ワイヤ。

【請求項４】　ワイヤ表面に砥粒が固着された固定砥粒付ワイヤを複数個のグルーブローラに巻き掛けてワイヤ列を形成し、該ワイヤ列を走行させながら被加工物を押し当てることにより、該被加工物を多数枚のウェーハに切断する固定砥粒ワイヤソーの切断方法において、

前記請求項１、または前記請求項２、または前記請求項３に記載の固定砥粒付ワイヤを用いるとともに、

前記被加工物の切断部分とその近傍に水溶性の加工液を噴射することを特徴とする固定砥粒ワイヤソーの切断方法。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は固定砥粒付ワイヤの構造及び該固定砥粒付ワイヤを用いた固定砥粒ワイヤソーの切断方法に係り、特にシリコン、ガラス、セラミックス等の脆性材料を切断する固定砥粒付ワイヤ及び固定砥粒ワイヤソーの切断方法に関する。

【０００２】

【従来の技術】棒状の材料（インゴット）を切断して薄板（ウェーハ）を製造する装置の一つにワイヤソーがある。ワイヤソーは所定のピッチで張架されたワイヤ列を高速走行させ、そのワイヤ列に被加工物を押し当てることにより多数枚のウェーハに同時に切断する装置である。

【０００３】このワイヤソーには従来から主に使用されている遊離砥粒方式による遊離砥粒ワイヤソーと、切断加工面の精度を向上させるとともに切断加工コスト低減の要求により近年開発されている固定砥粒方式による固定砥粒ワイヤソーがある。固定砥粒ワイヤソーは、ワイヤ全長にわたり表面に砥粒が固着された固定砥粒付ワイヤを用いてワイヤ列を形成し、そのワイヤ列を高速走行させることによりインゴットを切断する。

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【０００４】従来の固定砥粒付ワイヤの製造方法は、金属ワイヤの素線に砥粒を電着する方法であった。このワイヤの製造方法は、従来の円盤状薄板の金属ブレードの内周または外周に固定砥粒を電着して、該金属ブレードを高速回転することによりインゴットをウェーハ状の薄板に切断するスライシングマシンや、ダイシングマシンの頃からの金属ブレードに固定砥粒を付ける電着方法と同じであった。そのため、ワイヤに固着する砥粒は１種類の粒度であり、材質も１種類の材質の砥粒を用いていた。

【０００５】

【発明が解決しようとする課題】しかしながら、固定砥粒方式によるワイヤソーに於いては、固着された砥粒間にインゴットの切断粉が堆積し目詰まりし易い。このように砥粒間に切断粉が堆積すると切断性能が悪くなり、切断加工面のウェーハ表面にうねりを生じていた。この切断粉の堆積を少なくするために砥粒の集中度を下げると砥粒がワイヤから脱落し易くなり、ワイヤの寿命が短くなるので切断加工コストが上昇するという不具合を生じていた。

【０００６】切断能率を向上させるには、固定砥粒付ワイヤの砥粒にダイヤモンドを用いると切削性が良くなることは周知であるが、ダイヤモンド自体がたいへん高価であるので、生産レベルでダイヤモンド砥粒を用いて切断加工すると加工コストの面で不利であった。また、砥粒にＳｉＣやAl_2O_3を用いるとワイヤの生産コストは低いが、切断能率が悪いうえに、ワイヤに対する砥粒の固着力が低いことにより砥粒が脱落し易く固定砥粒付ワイヤの寿命が短いため、切断加工コストの低減には至らなかった。

【０００７】本発明はこのような事情に鑑みてなされたもので、固定砥粒付ワイヤによる切断加工において、被加工物の切断面精度を良好な状態に維持し、且つ、生産能率を向上するための固定砥粒付ワイヤと固定砥粒ワイヤソーの切断方法を提供することを目的とする。

【０００８】

【課題を解決するための手段】本発明は前記目的を達成するために、ワイヤ表面に砥粒が固着された固定砥粒付ワイヤを走行させながら被加工物を押し当てることにより該被加工物を切断する固定砥粒ワイヤソーにおいて、前記固定砥粒付ワイヤは、複数の異なった粒度を持つ砥粒が混在して固着されていること、且つ／又は、複数の異なった種類の材質で構成された砥粒が混在して固着されていることを特徴としている。

【０００９】本発明によれば、固定砥粒ワイヤソーに用いる固定砥粒付ワイヤに、複数の異なった粒度を持つ砥

粒が混在して固着されている、且つ／又は、複数の異なった種類の材質で構成された砥粒が混在して固着されている固定砥粒付ワイヤを用いたので、被加工物の切断面精度を良好な状態に維持し、且つ、生産能率の向上及び生産コストの低減を図ることができる。

【００１０】

【発明の実施の形態】以下添付図面に従って本発明に係る固定砥粒付ワイヤ及び固定砥粒ワイヤソーの好ましい形態について説明する。図１は、本発明に係る固定砥粒付ワイヤ１２が、被加工物であるインゴット３０を切断している状態を、固定砥粒付ワイヤ１２を誇張して示した断面図である。

【００１１】以下に、図１に示した固定砥粒付ワイヤ１２の構造について説明する。図１に示されるように、固定砥粒付きワイヤ１２は、高張力線材等の素材によるワイヤ素線１と、ダイヤモンド、ＣＢＮ、B_4C、ＳｉＣ、ＷＣ、ＴｉＣ、ＧＣ、アルミナ等の材質による比較的大きな大砥粒２と、ダイヤモンド、ＣＢＮ、B_4C、ＳｉＣ、ＷＣ、ＴｉＣ、ＧＣ、アルミナ等の材質による比較的小さな小砥粒３と、ワイヤ素線１と大砥粒２及び小砥粒３とを固着している固着材４（バインダー）とから構成されている。

【００１２】被加工物のインゴット３０の素材は、Ｓｉ（シリコン）、ＧａＡｓ、ＧａＰに代表される半導体材料や、磁性材、水晶、サファイヤ等である。なお、大砥粒２及び小砥粒３の固着方法については、ＣｏやＮｉ、Ｃｕ等の金属をバインダーとする電着による方法や、有機材料または無機材料による固着（熱硬化等）の樹脂固定等による方法を用いるが、本発明はこれらの方法に限定されるものではない。ただし、樹脂固定の方法によれば、容易に砥粒の集中度を下げることが可能である。また、ワイヤ素線１の材質は、ピアノ線や高抗張力非金属繊維線（ファイバ等を含む）でもよいし、該ワイヤ素線１に表面処理を行ってもよい。ワイヤ素線１の断面形状についても円形でも多角形でもよいし、構造についても単線であっても、撚り線であっても本発明の目的は達成される。一般にワイヤソーに於ける前記ワイヤ素線の線径は５０～３００μｍの範囲の素線を用いる。更に大砥粒２と小砥粒３の粒度についても限定されるものではなく、図１に示したように異なる２つの粒度でもよいし、異なる３つ以上の複数の粒度を持つ砥粒の混粒でもよい。例えば、大砥粒２の材質をダイヤモンドとしてその粒度をメッシュ２４０番とし、小砥粒３の材質をＳｉＣとしてその粒度をメッシュ８０００番のように組み合わせて、固着材４を用いてワイヤ１２に固着する。また、固着材４に気孔と呼ばれる空洞を設けることによって、切断粉５が砥粒と砥粒の間に堆積して切断能力が低下することを防ぐようにすることも可能である。

【００１３】図１の例では被加工物であるインゴット３０はワークフィードテーブル２８（図２参照）に固定されており、固定砥粒付ワイヤ１２が図１の８の方向に走行しながらインゴット３０を切断する。切断加工中はノズル付きの配管６から加工液７を噴射させて、該加工液７がインゴット３０の切断部及びその近傍にかかるようになっている。

【００１４】なお、インゴット３０の切断加工に際して切断粉５が発生する。加工液７は切断時に発生する加工熱を吸収し、切断時に生じる固定砥粒付ワイヤとインゴット３０間の切断抵抗を減じるとともに、固定砥粒付ワイヤ１２の各砥粒間に堆積した切断粉５の排出性を良くするために用いる液体で、水溶性のものと、油性のものとを用いることができる。水溶性の加工液は、比熱と熱伝導率が高いので加工熱を吸収し易いことに加えて、飛散した加工液の清掃が容易で作業環境が良好であるという特徴がある。また水溶性の加工液は、切断したウェーハの後工程に於いてウェーハに付着した加工液の洗浄が容易であるとともに、洗い流した加工液の産業廃棄物処理費用が安価であるという利点がある。

【００１５】図２は、図１で示した固定砥粒付ワイヤ１２を用いた固定砥粒ワイヤソーのワイヤ経路を示した図である。図２に示すように、固定砥粒付ワイヤ１２は、一対のワイヤリール１４Ａ、１４Ｂに巻回されており、固定砥粒付ワイヤ１２は、この一対のワイヤリール１４Ａ、１４Ｂ間を複数のガイドローラ１６、１６…に案内されながら往復走行する。図２に示した構造例に於いては、ワイヤ走行路にはそれぞれトラバース装置２２Ａ、２２Ｂ、ダンサローラ２４Ａ、２４Ｂが配置されている。トラバース装置２２Ａ、２２Ｂは、ワイヤリール１４Ａ、１４Ｂから固定砥粒付ワイヤ１２を一定の規則に従って案内し、また、ダンサローラ２４Ａ、２４Ｂは走行する固定砥粒付ワイヤ１２に一定の張力を付与する。前記一対のワイヤリール１４Ａ、１４Ｂには、それぞれモータ２６Ａ、２６Ｂが連結されており、このモータ２６Ａ、２６Ｂと、図示しないグルーブローラ１８、１８…を駆動するモータとを同期して駆動することにより、前記固定砥粒付ワイヤ１２が一対のワイヤリール１４Ａ、１４Ｂ間を走行する。そして、三本のグルーブローラ１８、１８、１８に、固定砥粒付ワイヤ１２が巻き掛けられ、水平な固定砥粒付ワイヤ１２のワイヤ列２０が形成される。前記ワイヤ列２０の下方にはワークフィードテーブル２８が設置されている。このワークフィードテーブル２８は、前記ワイヤ列２０に対して垂直に昇降移動し、このワークフィードテーブル２８の上部に被加工物であるインゴット３０が保持される。

【００１６】以上のように構成された固定砥粒ワイヤソー１０に於いて、インゴット３０は次のように切断される。まず、インゴット３０をワークフィードテーブル２８に取り付ける。次に、ワイヤリール１４Ａ、１４Ｂに連結されたモータ２６Ａ、２６Ｂと、図示しないグルーブローラ１８、１８…を駆動するモータとを同期駆動し

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て、固定砥粒付ワイヤ１２を走行させる。そして、固定砥粒付ワイヤ１２の走行が安定したところで、ワークフィードテーブル２８をワイヤ列２０に向けて上昇させ、インゴット３０を走行するワイヤ列２０に押し当てる。ワイヤ列２０に押し当てられたインゴット３０は、そのワイヤ列２０を構成する固定砥粒付ワイヤ１２によって接触部が研削され、これにより、ウェーハに切断される。

【００１７】以下に固定砥粒付ワイヤを用いた固定砥粒ワイヤソーに於ける被加工物の切断面精度と切断条件とについて説明する。固定砥粒ワイヤソーに於ける切断の際に被加工物の切断面精度を良くするためには、図３に示す切断中の固定砥粒付ワイヤ１２の撓みを少なくするとともに、この撓み量を一定に保つことが有効である。その理由は切断中の固定砥粒付ワイヤ１２の撓み量が大きいと前記撓み量に応じて固定砥粒付ワイヤ１２が蛇行し易くなり、ワイヤ列２０のワイヤ間隔が変動してウェーハ一枚一枚の切断面のうねりが増大するからである。そしてこのワイヤ１２の撓み量を少なく一定に保つことは、図３に示す固定砥粒付ワイヤ１２の走行方向に対して直角方向の切断抵抗ＦＺ（ｇ／ｃｍ）の値を小さく一定に保つことに等しい。ウェーハ切断面精度が悪化する原因である切断抵抗ＦＺが増えるのは、切断に対して固定砥粒付ワイヤ１２の大砥粒２、２…間に於ける切断粉５の排出性が悪いために切断粉排出能力が追いつかないことにより切断能力が低下するからである。

【００１８】そこで図４及び図５に固定砥粒付ワイヤの砥粒率である集中度Ｃ以外の切断条件を一定にして集中度Ｃのみ横軸にを変化させたときのウェーハ切断面のうねり量ＦＮ（μｍ）と、切断抵抗ＦＺ（ｇ／ｃｍ）との関係を調査した結果を示す。ここで、切断に使用した被加工物は固定砥粒付ワイヤ１２と被加工物との接触長を一定に保つ目的から、図２や図３に示されているような円筒形のインゴット３０ではなく角柱状のＳｉ単結晶インゴット（一辺２００ｍｍ）を用いている。円筒状のインゴット３０を切断する場合には単位時間当たりの切断仕事量を一定にするようにワイヤ走行速度を制御したり、切断送り速度を制御すると良い。図４、図５の計測条件は、切断送り速度は１（ｍｍ／ｍｉｎ）一定とし、ワイヤ張力：３５（Ｎ）、最大線速度：１８００（ｍ／ｍｉｎ）、双方向サイクル時間：３０（ｓｅｃ）、加減速時間：５（ｓｅｃ）、加工液：水＋水溶性クーラント３％、砥粒粒度：メッシュ＃６００番の単粒、ワイヤ素線径：０．１８（ｍｍ）の条件での切断に於けるウェーハ切断面うねり量ＦＮと、切断抵抗ＦＺとを示している。

【００１９】図４に示されるとおり、ウェーハ切断面うねり量ＦＮをウェーハ切断面うねり量許容値以下に抑えるためには固定砥粒付ワイヤの集中度Ｃを７５以下に設定すれば良いことがわかる。また前述したように図５によれば、切断抵抗ＦＺも集中度Ｃが７５以上で急激に増大することから、切断抵抗ＦＺが増大することに伴ってウェーハ切断面うねり量ＦＮが悪化すると言える。集中度とは、バインダーを含む砥粒層中にダイヤモンドやＣＢＮ等の砥粒が含まれている割合、すなわち砥粒率を示すものである。砥粒率が容積パーセントで２５％または４．４（ｃｔ／ｃｍ^3）を集中度１００と定義している（１ｃｔ＝２００ｍｇ）。なお、この集中度Ｃは、被加工物の材質に応じて２０～２００の値とすると良い。

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【００２０】固定砥粒ワイヤソーに於いて、ワイヤの固定砥粒の集中度を７５以下にすると被加工物であるウェーハ切断面うねり量が許容値以内に収まることは前述のとおりであるが、従来の切断条件のままであるとウェーハの加工変質層が深く、また、固定砥粒付ワイヤの大砥粒２、２…が切断時の抵抗により脱落し易いため固定砥粒付ワイヤの寿命が短いという不具合が発生する。一般的に固定砥粒付ワイヤは高価であるので、固定砥粒付ワイヤの寿命を延ばすことはウェーハの製造コストを下げる為に必須の課題である。加工変質層とは、削り痕に脆性モードが多く含まれている状態で、この脆性モードの削り痕が発生した場合には切断面にマイクロクラックが多数存在するために半導体生成用のウェーハとしては使用できない層である。逆に良好な切断加工面ではマイクロクラックは浅く、削り痕は延性モードとなっている。ウェーハの加工変質層が深いとウェーハ表面仕上げのための後工程でのラップ工程で多大な加工時間を要するのでウェーハの加工時間及び加工費が増大する。

【００２１】この加工変質層を浅くするには、ウェーハに対する砥粒一つ一つの切り込み量を減らせばよい。そのためには切断送り量を減らすか、ワイヤの走行速度を増すことが必要である。ワイヤソーでは、切断送り速度を遅くすると切断加工能率が低下するが、ワイヤ走行速度の向上は切断能率の面で有利である。本発明に係る固定砥粒付ワイヤを用いて切断加工することによって、従来の遊離砥粒ワイヤソーでは加工液の供給面で設定不可能であったワイヤ速度の高速化を図ることができる。

【００２２】図６にワイヤ走行速度Ｖ（ｍ／ｍｉｎ）と加工変質層深Ｄ（μｍ）との関係を測定した結果を示す。図６に示すとおり、加工変質層の深さは、ワイヤ走行速度１２００（ｍ／ｍｉｎ）以上で急激に減少しており、９００（ｍ／ｍｉｎ）時の約半分の５（μｍ）程になる。従来の遊離砥粒ワイヤソーでは砥粒が加工液中に含まれており、加工液中の砥粒により被加工物であるインゴットを切断していたため、加工液中の砥粒がワイヤに乗らず、切断部分に十分に引き込まれて行き渡らないと切断面のソーマークが過多になり、インゴット３０をきれいに切断できなかった。そのために遊離砥粒方式に於けるワイヤ走行速度の最大設定値は６００～８００（ｍ／ｍｉｎ）程度が限度であった。ところが固定砥粒ワイヤソーに於いては、加工液は切断部を潤滑する程度

存在すればよいため、ワイヤ走行速度の上限を上げることができる。

【００２３】図７にワイヤ走行速度Ｖ（ｍ／ｍｉｎ）を横軸に、切断抵抗ＦＺ（ｇｆ／ｃｍ）との関係を示す。図７に示すとおりワイヤ走行速度Ｖが増加するに従って切断抵抗ＦＺは減少する傾向がある。切断抵抗ＦＺが減少するとウェーハ切断面のうねり量が減少し良好なウェーハが得られる。

【００２４】これらの効果により、切断加工の能率を向上することができるとともに、切断面の加工変質層を薄くできるため良質なウェーハを安価にて製作することが可能となり、更に大砥粒２、２…の一つ一つに於ける切り込み量が減少するので大砥粒２、２…が脱落する確率が少なくなり固定砥粒付きワイヤの寿命を延ばすことが可能となる。

【００２５】更に、本発明に係る固定砥粒付ワイヤ及び固定砥粒ワイヤソーの加工方法の実施の形態によれば、切断に寄与する大砥粒２、２…が、小砥粒３、３…によって保持されながら固着材４によって固着されているので、従来の技術である固着材４のみによって大砥粒２、２…を固着する方法と比較して大砥粒２、２…の固着力が高く、大砥粒２、２…が脱落しにくい。また、切断に寄与する大砥粒２をダイヤモンドやＣＢＮとし、小砥粒３をダイヤモンドやＣＢＮに比較してはるかに安価なＳｉＣやＡｌ$_2$Ｏ$_3$とすることによって、切断能力が高い固定砥粒付ワイヤを安価にて提供することが可能となる。従って安価で長寿命な固定砥粒付ワイヤを提供することができるとともに、前記説明のとおりウェーハの切断加工面のうねりを少なくすることができ、更に次に示すように切断時間と切断コストの低減を図ることができる。

【００２６】図８に横軸にワイヤ走行速度Ｖ（ｍ／ｍｉｎ）を取り、縦軸にワイヤライフＷＬ（ｍｍ^2／ｍ）とした測定結果を示す。ここでワイヤライフＷＬとは、単位ワイヤ長さ（ｍ）当たりに於ける、大砥粒２の脱落無しに切断できたインゴットの切断面積（ｍｍ^2）を示している。従ってワイヤライフＦＬの値が大きいほどワイヤの寿命が長く、経済的であることを示している。図８によると、ワイヤ走行速度Ｖ＝１２００（ｍ／ｍｉｎ）以上になるとＶ＝９００（ｍ／ｍｉｎ）の状態に於けるワイヤライフと比べて２倍以上急に大きくなり、更にワイヤ走行速度Ｖを増すことによってワイヤライフＷＬの値は増加する。

【００２７】なお、ワイヤ走行速度を向上させるための手段としては、図示しないグループローラ１８、１８…の駆動モータ及びワイヤリールモータ２６Ａ、２６Ｂの高出力化（トルク、回転数向上）や、グループローラ１８、１８…の駆動減速比の変更、グループローラ１８、１８…の大径化、ワイヤリール１４Ａ、１４Ｂの軽量化、切断に使用する固定砥粒付ワイヤの量を減らしてワイヤリールモータ２６Ａ、２６Ｂにかかる負荷を減らす等の対策を組み合わせて対応する。

【００２８】

【発明の効果】以上説明したように、本発明に係る固定砥粒付ワイヤ及び固定砥粒ワイヤソーの切断方法によれば、固定砥粒ワイヤソーに用いる固定砥粒付ワイヤに、複数の異なった粒度を持つ砥粒が混在して固着されている、且つ／又は、複数の異なった種類の材質で構成された砥粒が混在して固着されている固定砥粒付ワイヤを用いたので、切断粉の排出性が良くなるとともに固定砥粒付ワイヤの寿命を延ばすことができる。更に、ウェーハの切断面のうねり量が減少するため、被加工物の切断面精度を良好にすることができることに加えて、生産能率の向上及び生産コストの低減を図ることができる。

【図面の簡単な説明】

【図１】本発明に係る固定砥粒付ワイヤ１２が、インゴット３０を切断している状態を固定砥粒ワイヤ１２を誇張して示した断面図。

【図２】固定砥粒ワイヤソーのワイヤ経路構成図。

【図３】固定砥粒付ワイヤ１２の走行方向に対して直角方向の切断抵抗ＦＺ（ｇ／ｃｍ）の値を示す図。

【図４】集中度Ｃを横軸に変化させたときのウェーハ切断面のうねり量ＦＮ（μｍ）との関係を示す図。

【図５】集中度Ｃを横軸に変化させたときの切断抵抗ＦＺ（ｇ／ｃｍ）との関係を示す図。

【図６】ワイヤ走行速度Ｖ（ｍ／ｍｉｎ）を横軸に変化させたときの加工変質層深さＤ（μｍ）との関係を示す図。

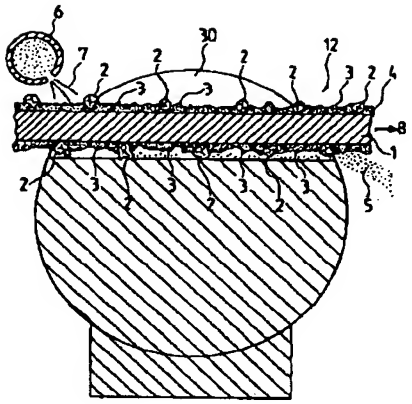
【図７】ワイヤ走行速度Ｖ（ｍ／ｍｉｎ）を横軸に変化させたときの切断抵抗ＦＺ（ｇ／ｃｍ）との関係を示す図。

【図８】ワイヤ走行速度Ｖ（ｍ／ｍｉｎ）を横軸に変化させたときのワイヤライフＷＬ（ｍｍ^2／ｍ）との関係を示す図。

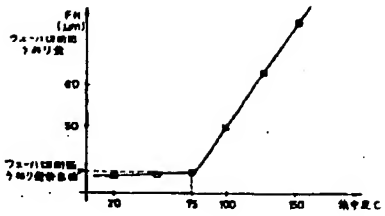
【符号の説明】

１…ワイヤ素線
２…大砥粒
３…小砥粒
４…固着材
５…切断粉
７…加工液
１０…固定砥粒ワイヤソー
１２…固定砥粒付ワイヤ
３０…インゴット

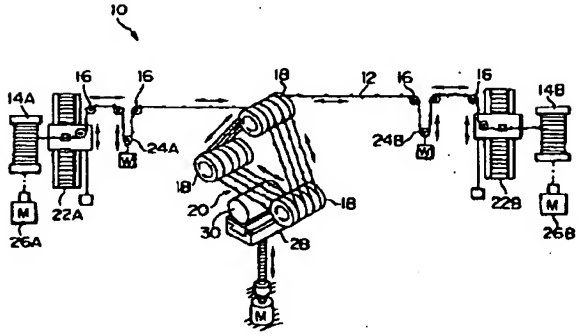
【図１】



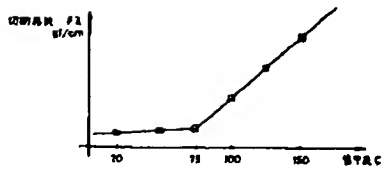
【図４】



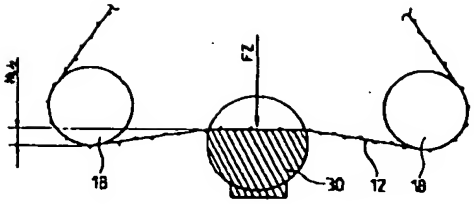
【図２】



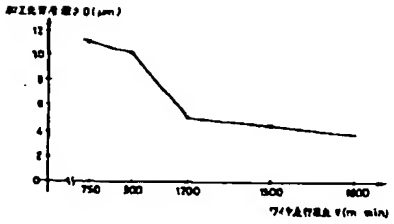
【図５】



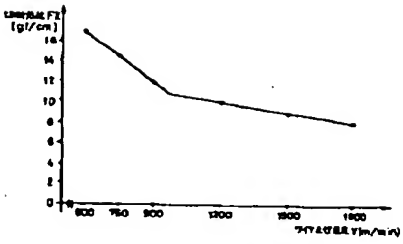
【図３】



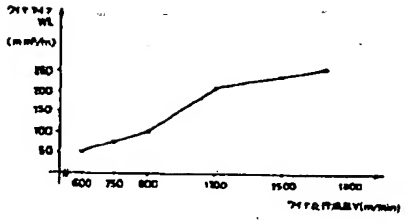
【図６】



【図７】



【図８】



フロントページの続き

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　　3C069 AA01 BA06 BB02 BB04 CA04
　　EA01 EA02 EA03

* NOTICES *

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CLAIMS

[Claim(s)]
[Claim 1] By pressing a workpiece, running a wire front face the wire with bonded abrasive which the abrasive grain fixed, it is the wire with bonded abrasive characterized by having intermingled the abrasive grain in which said wire with bonded abrasive has the grain size from which plurality differed in the wire with bonded abrasive which cuts this workpiece, and having fixed.
[Claim 2] By pressing a workpiece, running a wire front face the wire with bonded abrasive which the abrasive grain fixed, it is the wire with bonded abrasive characterized by having intermingled the abrasive grain with which said wire with bonded abrasive consisted of the quality of the materials of two or more different classes in the wire with bonded abrasive which cuts this workpiece, and having fixed.
[Claim 3] By pressing a workpiece, running a wire front face the wire with bonded abrasive which the abrasive grain fixed, it is the wire with bonded abrasive characterized by having intermingled the abrasive grain with which said wire with bonded abrasive consisted of two or more different grain size and the quality of the material of two or more different classes in the wire with bonded abrasive which cuts this workpiece, and having fixed.
[Claim 4] By pressing a workpiece, winding around two or more groove rollers almost the wire with bonded abrasive which the abrasive grain fixed on the wire front face, forming a wire train, and making it run this wire train this workpiece -- many -- in the cutting process of the bonded abrasive wire saw cut to several wafers, while using said claim 1, said claim 2, or said wire with bonded abrasive according to claim 3 Cutting process of the bonded abrasive wire saw characterized by injecting water-soluble working liquid a cutting part and near said workpiece.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the cutting process of the wire with bonded abrasive and bonded abrasive wire saw which start the cutting process of the bonded abrasive wire saw which used the structure of a wire with bonded abrasive, and this wire with bonded abrasive, especially cut brittle materials, such as silicon, glass, and ceramics.
[0002]
[Description of the Prior Art] A wire saw is in one of the equipment which cuts a rod-like ingredient (ingot) and manufactures sheet metal (wafer). a wire saw carrying out high-speed transit of the wire train laid in the predetermined pitch, and pressing a workpiece against the wire train -- many -- it is equipment cut to several wafers at coincidence.
[0003] There are a loose grain wire saw by the loose grain method mainly used for this wire saw from the former and a bonded abrasive wire saw by the bonded abrasive method developed by the demand of cutting processing cost reduction in recent years while raising the precision of a cutting processing side. A bonded abrasive wire saw forms a wire train in a front face using the wire with bonded abrasive which the abrasive grain fixed covering a wire overall length, and cuts an ingot by carrying out high-speed transit of the wire train.
[0004] The manufacture approach of the conventional wire with bonded abrasive was the approach of electrodepositing an abrasive grain in the strand of a metal wire. The manufacture approach of this wire was the same as the slicing machine which cuts an ingot to wafer-like sheet metal, and the anode process which attaches bonded abrasive to a metal blade from the time of a dicing machine by electrodepositing bonded abrasive on the conventional inner circumference or the conventional periphery of a metal blade of disc-like sheet metal, and carrying out high-speed rotation of this metal blade. Therefore,

the abrasive grain which fixes on a wire is one kind of grain size, and the quality of the material also used the abrasive grain of one kind of quality of the material.
[0005]
[Problem(s) to be Solved by the Invention] However, in the wire saw by the bonded abrasive method, it accumulates and is easy to carry out blinding of the cutting powder of an ingot between the abrasive grains which fixed. Thus, when cutting powder accumulated between abrasive grains, sectility ability worsened and had produced the wave on the wafer front face of a cutting processing side. Since the abrasive grain dedrop came to be easy from a wire and the life of a wire became short when the degree of concentration of an abrasive grain was lowered, in order to lessen deposition of this cutting powder, the fault that cutting processing cost went up had been produced.
[0006] In order to have raised cutting efficiency, when the diamond was used for the abrasive grain of a wire with bonded abrasive, it was common knowledge that cutting ability becomes good, but since the diamond itself was very expensive, when cutting processing was carried out using the diamond abrasive grain on production level, it was disadvantageous in respect of processing cost. Moreover, they are SiC and aluminum 2O3 to an abrasive grain. When used, the production cost of a wire was low, but omitted [that the fixing force of an abrasive grain over a wire is low / an abrasive grain / tend], since the life of a wire with bonded abrasive was short, the top where cutting efficiency is bad was not reached at reduction of cutting processing cost.
[0007] It aims at offering a wire with bonded abrasive having made this invention in view of such a situation, and maintaining the cutting profile irregularity of a workpiece in the good condition in cutting processing with a wire with bonded abrasive, and improving production efficiency, and the cutting process of a bonded abrasive wire saw.
[0008]
[Means for Solving the Problem] In the bonded abrasive wire saw which cuts this workpiece by pressing a workpiece, running a wire front face the wire with bonded abrasive which the abrasive grain fixed in order that this invention may attain said purpose Said wire with bonded abrasive is characterized by that the abrasive grain with the grain size from which plurality differed has intermingled and fixed and/, or the abrasive grain that consisted of the quality of the materials of the class from which plurality differed having intermingled and fixed.
[0009] The abrasive grain which has the grain size from which plurality differed in the wire with bonded abrasive used for a bonded abrasive wire saw according to this invention can be intermingled, it has fixed, and since the wire with bonded abrasive which/or the abrasive grain which consisted of the quality of the materials of two or more different classes has intermingled for which and fixed was used, the cutting profile irregularity of a workpiece can be maintained in the good condition, and improvement in

production efficiency and reduction of a production cost can be aimed at.
[0010]
[Embodiment of the Invention] The desirable gestalt of the wire with bonded abrasive applied to this invention according to an accompanying drawing below and a bonded abrasive wire saw is explained. Drawing 1 is the sectional view in which the wire 12 with bonded abrasive concerning this invention exaggerated the wire 12 with bonded abrasive, and showed the condition of cutting the ingot 30 which is a workpiece.
[0011] Below, the structure of the wire 12 with bonded abrasive shown in drawing 1 is explained. As shown in drawing 1 , the wire 12 with bonded abrasive The wire strand 1 by materials, such as a high tension wire rod, and the comparatively big large abrasive grain 2 by the quality of the material of a diamond, CBN, B4 C, SiC, WC, TiC, and GC, an alumina, etc., It consists of fixing material 4 (binder) which has fixed the comparatively small small abrasive grain 3 by the quality of the material, and the wire strand 1, the large abrasive grain 2 and the small abrasive grain 3 of a diamond, CBN, B4 C, SiC, WC, TiC, and GC, an alumina, etc.
[0012] The materials of the ingot 30 of a workpiece are the semiconductor material represented by Si (silicon), GaAs, and GaP, magnetic material, Xtal, sapphire, etc. In addition, although the approach by the approach by the electrodeposition which uses metals, such as Co, and nickel, Cu, as a binder, resin immobilization of fixing (heat curing etc.) by the organic material or the inorganic material, etc. is used about the fixing approach of the large abrasive grain 2 and the small abrasive grain 3, this invention is not limited to these approaches. However, according to the approach of resin immobilization, it is possible to lower the degree of concentration of an abrasive grain easily. Moreover, piano wire and a high-tensile-strength nonmetal fiber line (a fiber etc. is included) are sufficient as the quality of the material of the wire strand 1, and it may perform surface treatment to this wire strand 1. It may be circular also about the cross-section configuration of the wire strand 1, or a polygon is sufficient, and also about structure, even if it is single track, and it is a twist line, the purpose of this invention is attained. Generally the wire size of said wire strand in a wire saw uses the strand of the range of 50-300 micrometers. Furthermore, two grain size which is different as it is not limited about the grain size of the large abrasive grain 2 and the small abrasive grain 3, either and was shown in drawing 1 is sufficient, and the mixed grain size of an abrasive grain with two or more three or more different grain size is sufficient. For example, the grain size is made into the mesh of No. 240 by using the quality of the material of the large abrasive grain 2 as a diamond, and it fixes on a wire 12 using the fixing material 4 by setting the quality of the material of the small abrasive grain 3 to SiC, combining the grain size like the mesh of No. 8000. Moreover, it is also possible to prevent the cutting powder's 5 accumulating between abrasive grains, and cutting capacity declining by preparing the

cavity called pore to the fixing material 4.
[0013] In the example of drawing 1 , it is fixed to the work-piece feed table 28 (refer to drawing 2), and the ingot 30 which is a workpiece cuts an ingot 30, while the wire 12 with bonded abrasive runs in the direction of 8 of drawing 1 . During cutting processing, working liquid 7 is made to inject from the piping 6 with a nozzle, and this working liquid 7 is applied to the cutting section of an ingot 30, and its near.
[0014] In addition, the cutting powder 5 is generated on the occasion of cutting processing of an ingot 30. Working liquid 7 absorbs the temperature increase by plastic working generated at the time of cutting, is the liquid used in order to improve eccritic [of the cutting powder 5 deposited between each abrasive grain of the wire 12 with bonded abrasive], and can use a water-soluble thing and an oily thing while it reduces the cutting resistance between the wire with bonded abrasive produced at the time of cutting, and an ingot 30. Since the specific heat and thermal conductivity are high, in addition to being easy to absorb temperature increase by plastic working, water-soluble working liquid has the description that cleaning of the working liquid which dispersed is easy and work environment is good. Moreover, it has the advantage that the object for the industrial waste disposal costs of the flushed working liquid is cheap while washing of the working liquid which adhered to the wafer in the back process of the cut wafer is easy for water-soluble working liquid.
[0015] Drawing 2 is drawing having shown the wire path of the bonded abrasive wire saw using the wire 12 with bonded abrasive shown by drawing 1 . As shown in drawing 2 , the wire 12 with bonded abrasive is wound around the wire reels 14A and 14B of a pair, and while the wire 12 with bonded abrasive is guided in between wire reel 14A of this pair, and 14B at two or more guide idlers 16 and 16 --, it carries out both-way transit. In the example of structure shown in drawing 2 , the traverse equipments 22A and 22B and dancer roller devices 24A and 24B are arranged on the wire transit way, respectively. The traverse equipments 22A and 22B guide the wire 12 with bonded abrasive according to a fixed regulation from wire reels 14A and 14B, and dancer roller devices 24A and 24B give fixed tension to the wire 12 with bonded abrasive it runs. Motors 26A and 26B are connected with the wire reels 14A and 14B of said pair, respectively, and said wire 12 with bonded abrasive runs between wire reel 14A of a pair, and 14B by driving synchronously these motors 26A and 26B, and the groove roller 18 which is not illustrated and the motor which drives 18 --. And the wire 12 with bonded abrasive is almost wound around three groove rollers 18, 18, and 18, and the wire train 20 of the level wire 12 with bonded abrasive is formed. The work-piece feed table 28 is installed under said wire train 20. This work-piece feed table 28 carries out rise-and-fall migration perpendicularly to said wire train 20, and the ingot 30 which is a workpiece is held in the upper part of this work-piece feed table 28.

[0016] In the bonded abrasive wire saw 10 constituted as mentioned above, an ingot 30 is cut as follows. First, an ingot 30 is attached in the work-piece feed table 28. Next, the synchronous drive of the motors 26A and 26B connected with wire reels 14A and 14B, and the groove roller 18 which is not illustrated and the motor which drives 18 -- is carried out, and it is made to run the wire 12 with bonded abrasive. And the work-piece feed table 28 is turned and raised in the wire train 20 in the place by which transit of the wire 12 with bonded abrasive was stabilized, and it presses against the wire train 20 which runs an ingot 30. With the wire 12 with bonded abrasive which constitutes the wire train 20, grinding of the contact section is carried out and, thereby, the ingot 30 pressed against the wire train 20 is cut by the wafer.

[0017] The cutting profile irregularity of a workpiece and the cutting conditions in the bonded abrasive wire saw which used the wire with bonded abrasive for below are explained. In order to improve cutting profile irregularity of a workpiece in the case of cutting in a bonded abrasive wire saw, while lessening bending of the wire 12 with bonded abrasive under cutting shown in drawing 3 , it is effective to keep this amount of bending constant. The reason is that the wire 12 with bonded abrasive will become easy to move in a zigzag direction according to said amount of bending, wire spacing of the wire train 20 will be changed, and the wave of an one-sheet wafer [one sheet] cutting plane will increase if the amount of bending of the wire 12 with bonded abrasive under cutting is large. And it is equal to keeping constant small the value of the cutting resistance FZ (g/cm) of the direction of a right angle to the transit direction of the wire 12 with bonded abrasive shown in drawing 3 to keep constant the amount of bending of this wire 12 few. It is the large abrasive grains 2 and 2 of the wire 12 with bonded abrasive to cutting that the cutting resistance FZ which is the cause by which wafer cutting profile irregularity gets worse increases. -- It is because eccritic [of the cutting powder 5 of a between] is bad, so cutting capacity declines when cutting powder discharge capacity does not catch up.

[0018] Then, the result of having investigated the amount FN (micrometer) of external waviness of a wafer cutting plane when cutting conditions other than the degree of concentration C which is the grain ratio of a wire with bonded abrasive are fixed and only degree of concentration C changes ****** to drawing 4 and drawing 5 , and relation with the cutting resistance FZ (g/cm) is shown. Here, the workpiece used for cutting uses not the ingot 30 but prismatic form Si single crystal ingot (200mm per side) of a cylindrical shape as shown in drawing 2 or drawing 3 from the purpose which keeps constant the contact length of the wire 12 with bonded abrasive, and a workpiece. When cutting the cylinder-like ingot 30, it is good to control a wire travel speed or to control a cutting feed rate to make regularity the cutting workload per unit time amount. It is supposed that it is fixed. drawing 4 and the measurement conditions of drawing 5 -- a cutting feed rate -- 1

(mm/min) -- Wire tension [redacted](N) maximum linear-velocity[redacted]00 (m/min), bidirectional cycle-time:30 (sec), acceleration-and-deceleration time amount: -- a simple grain (5 (sec), working liquid:water + water solubility coolant 3%, and abrasive grain grain-size:mesh #600 No.) and diameter of wire strand: -- the wafer cutting plane in cutting on the conditions of 0.18 (mm) -- a wave -- an amount FN and the cutting resistance FZ are shown.

[0019] as being shown in drawing 4 -- a wafer cutting plane -- a wave -- an amount FN -- a wafer cutting plane -- a wave -- in order to hold down to below an amount allowed value, it turns out that what is necessary is just to set the degree of concentration C of a wire with bonded abrasive or less to 75. Moreover, as mentioned above, since degree of concentration C increases rapidly or more by 75, according to drawing 5 , the cutting resistance FZ can also be referred to as getting worse the amount FN of wafer cutting plane external waviness in connection with what the cutting resistance FZ increases. Degree of concentration shows the rate, i.e., a grain ratio, that abrasive grains, such as a diamond and CBN, are contained in the abrasive grain layer containing a binder. The grain ratio defines 25% or 4.4 (ct/cm3) as degree of concentration 100 by the percent by volume (1ct=200mg). In addition, this degree of concentration C is good to consider as the value of 20-200 according to the quality of the material of a workpiece.

[0020] the wafer cutting plane which is a workpiece when degree of concentration of the bonded abrasive of a wire is made or less into 75 in a bonded abrasive wire saw -- a wave -- although it is as above-mentioned that an amount is settled within an allowed value, they are still the conventional cutting conditions -- the damaged layer of a wafer -- deep -- moreover, the large abrasive grain 2 of a wire with bonded abrasive and 2 -- the resistance at the time of cutting -- dedropping -- being easy -- a sake -- a wire with bonded abrasive -- the fault that a life is short occurs. Since the wire with bonded abrasive is generally expensive, it is an indispensable technical problem to prolong the life of a wire with bonded abrasive, in order to lower the manufacturing cost of a wafer. A damaged layer is in the condition that many brittle modes are contained in shaving marks, and since many micro cracks exist in a cutting plane when the shaving marks in this brittle mode occur, it is a layer which cannot be used as a wafer for semi-conductor generation. Conversely, in respect of good cutting processing, a micro crack is shallow, and shaving marks serve as ductility mode. Since the lap process in the back process for wafer surface finish will take great floor to floor time if the damaged layer of a wafer is deep, the floor to floor time and the conversion cost of a wafer increase.

[0021] What is necessary is just to reduce the amount of slitting of abrasive grain each to a wafer, in order to make this damaged layer shallow. It is required to reduce a cutting feed per revolution for that purpose, or to gather the travel speed of a wire. Although cutting processing efficiency will fall in a wire saw if a cutting feed rate is made late, the

improvement in a wire travel speed is advantageous in respect of cutting efficiency. By carrying out cutting processing using the wire with bonded abrasive concerning this invention, improvement in the speed of the wire rate which was not able to be set up in respect of supply of working liquid can be attained by the conventional loose grain wire saw.

[0022] The result of having measured the relation between the wire travel speed V (m/min) and the processing deterioration layer depth D (micrometer) to drawing 6 is shown. Above wire travel-speed 1200 (m/min), the depth of a damaged layer is decreasing rapidly and becomes like 5 (micrometer) of the abbreviation one half at the 900 (m/min) time as shown in drawing 6 . In the conventional loose grain wire saw, since the abrasive grain is contained in working liquid and the abrasive grain in working liquid was cutting the ingot which is a workpiece, unless the abrasive grain in working liquid did not ride on the wire, but was fully drawn in the cutting part and spread, the saw mark of a cutting plane became excessive and was not able to cut an ingot 30 finely. Therefore, 600 to 800 (m/min) extent of the maximum set point of the wire travel speed in a loose grain method was a limit. However, in a bonded abrasive wire saw, since [which carries out the lubrication of the cutting section] what is necessary is just to recognize extent existence, working liquid can raise the upper limit of a wire travel speed.

[0023] The wire travel speed V (m/min) is shown in drawing 7 , and relation with the cutting resistance FZ (gf/cm) is shown on an axis of abscissa. It is alike, therefore the cutting resistance FZ tends [which the wire travel speed V increases] to decrease as shown in drawing 7 . If the cutting resistance FZ decreases, the amount of external waviness of a wafer cutting plane will decrease, and a good wafer will be obtained.

[0024] Since the damaged layer of a cutting plane can be made thin, it becomes possible to ****** a good wafer cheaply and the large abrasive grain 2 and the amount of slitting in each of 2 -- decrease further according to such effectiveness while being able to improve the efficiency of cutting processing, it becomes possible for the large abrasive grain 2 and the probability for 2 -- to drop out to decrease, and to prolong the life of a wire with bonded abrasive.

[0025] Furthermore, since the large abrasive grain 2 and 2 -- which contribute to cutting have fixed by the fixing material 4 according to the gestalt of implementation of the processing approach of the wire with bonded abrasive concerning this invention, and a bonded abrasive wire saw, being held by the small abrasive grain 3 and 3 -- Only the fixing material 4 which is a Prior art compares with the large abrasive grain 2 and the approach of fixing 2 --, and they are the large abrasive grains 2 and 2. -- The fixing force is high and the large abrasive grain 2 and 2 -- are a pile to dedropping. Moreover, the large abrasive grain 2 contributed to cutting is set to a diamond or CBN, the small abrasive grain 3 is compared with a diamond or CBN, and it is far cheap SiC and

aluminum 2O3. By carrying out, cutting capacity becomes possible [******(ing) a high wire with bonded abrasive cheaply]. Therefore, while being able to offer a cheap and long lasting wire with bonded abrasive, as said explanation, the wave of the cutting processing side of a wafer can be lessened, and as shown further below, reduction of cutting time amount and cutting cost can be aimed at.

[0026] The wire travel speed V (m/min) is taken along an axis of abscissa at drawing 8 , and the measurement result made into the wire life WL (mm2/m) at the axis of ordinate is shown. here -- the wire life WL -- unit wire die length -- (-- the cutting area (mm2) of the ingot currently cut without omission of the large abrasive grain 2 in per [m)] is shown. Therefore, it is shown that the life of a wire is so long that the value of the wire life floor line is large, and it is economical. According to drawing 8 , if it becomes more than wire travel-speed V=1200 (m/min), compared with the wire life in the condition of V= 900 (m/min), it will become large suddenly more than twice, and the value of the wire life WL increases by gathering the wire travel speed V further.

[0027] in addition, as a means for raising a wire travel speed The groove roller 18 which is not illustrated and 18 -- Drive-motor and wire reel motor 26A, The high increase in power (torque, improvement in an engine speed) of 26B, and the groove roller 18 and 18 -- Modification of a drive reduction gear ratio, It corresponds combining a cure, such as reducing the load which reduces the amount of the groove roller 18 and the wire with bonded abrasive of 18 -- used for major-diameter-izing, lightweight-izing of wire reels 14A and 14B, and cutting, and is applied to the wire reel motors 26A and 26B.

[0028]

[Effect of the Invention] As explained above, according to the cutting process of the wire with bonded abrasive concerning this invention, and a bonded abrasive wire saw The abrasive grain which has the grain size from which plurality differed in the wire with bonded abrasive used for a bonded abrasive wire saw has intermingled and fixed. / Or since the wire with bonded abrasive which the abrasive grain which consisted of the quality of the materials of the class from which plurality differed has intermingled for which and fixed was used, while eccritic [of cutting powder] becomes good, the life of a wire with bonded abrasive can be prolonged. furthermore, the wave of the cutting plane of a wafer -- since an amount decreases, cutting profile irregularity of a workpiece can be made good -- in addition, improvement in production efficiency and reduction of a production cost can be aimed at.

[Translation done.]

* NOTICES *

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TECHNICAL FIELD

[Field of the Invention] This invention relates to the cutting process of the wire with bonded abrasive and bonded abrasive wire saw which start the cutting process of the bonded abrasive wire saw which used the structure of a wire with bonded abrasive, and this wire with bonded abrasive, especially cut brittle materials, such as silicon, glass, and ceramics.

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PRIOR ART

[Description of the Prior Art] A wire saw is in one of the equipment which cuts a rod-like ingredient (ingot) and manufactures sheet metal (wafer). a wire saw carrying out high-speed transit of the wire train laid in the predetermined pitch, and pressing a workpiece against the wire train -- many -- it is equipment cut to several wafers at coincidence.
[0003] There are a loose grain wire saw by the loose grain method mainly used for this wire saw from the former and a bonded abrasive wire saw by the bonded abrasive method developed by the demand of cutting processing cost reduction in recent years while raising the precision of a cutting processing side. A bonded abrasive wire saw forms a wire train in a front face using the wire with bonded abrasive which the abrasive grain fixed covering a wire overall length, and cuts an ingot by carrying out high-speed transit of the wire train.
[0004] The manufacture approach of the conventional wire with bonded abrasive was the approach of electrodepositing an abrasive grain in the strand of a metal wire. The manufacture approach of this wire was the same as the slicing machine which cuts an ingot to wafer-like sheet metal, and the anode process which attaches bonded abrasive to a metal blade from the time of a dicing machine by electrodepositing bonded abrasive on the conventional inner circumference or the conventional periphery of a metal blade of disc-like sheet metal, and carrying out high-speed rotation of this metal blade. Therefore, the abrasive grain which fixes on a wire is one kind of grain size, and the quality of the material also used the abrasive grain of one kind of quality of the material.

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EFFECT OF THE INVENTION

[Effect of the Invention] As explained above, according to the cutting process of the wire with bonded abrasive concerning this invention, and a bonded abrasive wire saw, the abrasive grain which has the grain size from which plurality differed in the wire with bonded abrasive used for a bonded abrasive wire saw is intermingled. Since it has fixed and/or the wire with bonded abrasive which the abrasive grain which consisted of the quality of the materials of the class from which plurality differed has intermingled for which and fixed was used, while eccritic [of cutting powder] becomes good, the life of a wire with bonded abrasive can be prolonged. furthermore, the wave of the cutting plane of a wafer -- since an amount decreases, cutting profile irregularity of a workpiece can be made good -- in addition, improvement in production efficiency and reduction of a production cost can be aimed at.

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TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] However, in the wire saw by the bonded abrasive method, it accumulates and is easy to carry out blinding of the cutting powder of an ingot between the abrasive grains which fixed. Thus, when cutting powder accumulated between abrasive grains, sectility ability worsened and had produced the wave on the wafer front face of a cutting processing side. Since the abrasive grain dedrop came to be easy from a wire and the life of a wire became short when the degree of concentration of an abrasive grain was lowered, in order to lessen deposition of this cutting powder, the fault that cutting processing cost went up had been produced.
[0006] In order to have raised cutting efficiency, when the diamond was used for the abrasive grain of a wire with bonded abrasive, it was common knowledge that cutting ability becomes good, but since the diamond itself was very expensive, when cutting processing was carried out using the diamond abrasive grain on production level, it was disadvantageous in respect of processing cost. Moreover, they are SiC and aluminum 2O3 to an abrasive grain. When used, the production cost of a wire was low, but omitted [that the fixing force of an abrasive grain over a wire is low / an abrasive grain / tend], since the life of a wire with bonded abrasive was short, the top where cutting efficiency is bad was not reached at reduction of cutting processing cost.
[0007] It aims at offering a wire with bonded abrasive having made this invention in view of such a situation, and maintaining the cutting profile irregularity of a workpiece in the good condition in cutting processing with a wire with bonded abrasive, and improving production efficiency, and the cutting process of a bonded abrasive wire saw.

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MEANS

[Means for Solving the Problem] In the bonded abrasive wire saw which cuts this workpiece by pressing a workpiece, running a wire front face the wire with bonded abrasive which the abrasive grain fixed in order that this invention may attain said purpose Said wire with bonded abrasive is characterized by that the abrasive grain with the grain size from which plurality differed has intermingled and fixed and/, or the abrasive grain that consisted of the quality of the materials of the class from which plurality differed having intermingled and fixed.
[0009] The abrasive grain which has the grain size from which plurality differed in the wire with bonded abrasive used for a bonded abrasive wire saw according to this invention can be intermingled, it has fixed, and since the wire with bonded abrasive which/or the abrasive grain which consisted of the quality of the materials of two or more different classes has intermingled for which and fixed was used, the cutting profile irregularity of a workpiece can be maintained in the good condition, and improvement in production efficiency and reduction of a production cost can be aimed at.
[0010]
[Embodiment of the Invention] The desirable gestalt of the wire with bonded abrasive applied to this invention according to an accompanying drawing below and a bonded abrasive wire saw is explained. Drawing 1 is the sectional view in which the wire 12 with bonded abrasive concerning this invention exaggerated the wire 12 with bonded abrasive, and showed the condition of cutting the ingot 30 which is a workpiece.
[0011] Below, the structure of the wire 12 with bonded abrasive shown in drawing 1 is explained. As shown in drawing 1 , the wire 12 with bonded abrasive The wire strand 1 by materials, such as a high tension wire rod, and the comparatively big large abrasive grain 2 by the quality of the material of a diamond, CBN, B4 C, SiC, WC, TiC, and GC, an alumina, etc., It consists of fixing material 4 (binder) which has fixed the comparatively small small abrasive grain 3 by the quality of the material, and the wire

strand 1, the large abrasive grain 2 and the small abrasive grain 3 of a diamond, CBN, B4 C, SiC, WC, TiC, and GC, an alumina, etc.

[0012] The materials of the ingot 30 of a workpiece are the semiconductor material represented by Si (silicon), GaAs, and GaP, magnetic material, Xtal, sapphire, etc. In addition, although the approach by the approach by the electrodeposition which uses metals, such as Co, and nickel, Cu, as a binder, resin immobilization of fixing (heat curing etc.) by the organic material or the inorganic material, etc. is used about the fixing approach of the large abrasive grain 2 and the small abrasive grain 3, this invention is not limited to these approaches. However, according to the approach of resin immobilization, it is possible to lower the degree of concentration of an abrasive grain easily. Moreover, piano wire and a high-tensile-strength nonmetal fiber line (a fiber etc. is included) are sufficient as the quality of the material of the wire strand 1, and it may perform surface treatment to this wire strand 1. It may be circular also about the cross-section configuration of the wire strand 1, or a polygon is sufficient, and also about structure, even if it is single track, and it is a twist line, the purpose of this invention is attained. Generally the wire size of said wire strand in a wire saw uses the strand of the range of 50-300 micrometers. Furthermore, two grain size which is different as it is not limited about the grain size of the large abrasive grain 2 and the small abrasive grain 3, either and was shown in drawing 1 is sufficient, and the mixed grain size of an abrasive grain with two or more three or more different grain size is sufficient. For example, the grain size is made into the mesh of No. 240 by using the quality of the material of the large abrasive grain 2 as a diamond, and it fixes on a wire 12 using the fixing material 4 by setting the quality of the material of the small abrasive grain 3 to SiC, combining the grain size like the mesh of No. 8000. Moreover, it is also possible to prevent the cutting powder's 5 accumulating between abrasive grains, and cutting capacity declining by preparing the cavity called pore to the fixing material 4.

[0013] In the example of drawing 1 , it is fixed to the work-piece feed table 28 (refer to drawing 2), and the ingot 30 which is a workpiece cuts an ingot 30, while the wire 12 with bonded abrasive runs in the direction of 8 of drawing 1 . During cutting processing, working liquid 7 is made to inject from the piping 6 with a nozzle, and this working liquid 7 is applied to the cutting section of an ingot 30, and its near.

[0014] In addition, the cutting powder 5 is generated on the occasion of cutting processing of an ingot 30. Working liquid 7 absorbs the temperature increase by plastic working generated at the time of cutting, is the liquid used in order to improve eccritic [of the cutting powder 5 deposited between each abrasive grain of the wire 12 with bonded abrasive], and can use a water-soluble thing and an oily thing while it reduces the cutting resistance between the wire with bonded abrasive produced at the time of cutting, and an ingot 30. Since the specific heat and thermal conductivity are high, in

addition to being easy to absorb temperature increase by plastic working, water-soluble working liquid has the description that cleaning of the working liquid which dispersed is easy and work environment is good. Moreover, it has the advantage that the object for the industrial waste disposal costs of the flushed working liquid is cheap while washing of the working liquid which adhered to the wafer in the back process of the cut wafer is easy for water-soluble working liquid.

[0015] Drawing 2 is drawing having shown the wire path of the bonded abrasive wire saw using the wire 12 with bonded abrasive shown by drawing 1 . As shown in drawing 2 , the wire 12 with bonded abrasive is wound around the wire reels 14A and 14B of a pair, and while the wire 12 with bonded abrasive is guided in between wire reel 14A of this pair, and 14B at two or more guide idlers 16 and 16 --, it carries out both-way transit. In the example of structure shown in drawing 2 , the traverse equipments 22A and 22B and dancer roller devices 24A and 24B are arranged on the wire transit way, respectively. The traverse equipments 22A and 22B guide the wire 12 with bonded abrasive according to a fixed regulation from wire reels 14A and 14B, and dancer roller devices 24A and 24B give fixed tension to the wire 12 with bonded abrasive it runs. Motors 26A and 26B are connected with the wire reels 14A and 14B of said pair, respectively, and said wire 12 with bonded abrasive runs between wire reel 14A of a pair, and 14B by driving synchronously these motors 26A and 26B, and the groove roller 18 which is not illustrated and the motor which drives 18 --. And the wire 12 with bonded abrasive is almost wound around three groove rollers 18, 18, and 18, and the wire train 20 of the level wire 12 with bonded abrasive is formed. The work-piece feed table 28 is installed under said wire train 20. This work-piece feed table 28 carries out rise-and-fall migration perpendicularly to said wire train 20, and the ingot 30 which is a workpiece is held in the upper part of this work-piece feed table 28.

[0016] In the bonded abrasive wire saw 10 constituted as mentioned above, an ingot 30 is cut as follows. First, an ingot 30 is attached in the work-piece feed table 28. Next, the synchronous drive of the motors 26A and 26B connected with wire reels 14A and 14B, and the groove roller 18 which is not illustrated and the motor which drives 18 -- is carried out, and it is made to run the wire 12 with bonded abrasive. And the work-piece feed table 28 is turned and raised in the wire train 20 in the place by which transit of the wire 12 with bonded abrasive was stabilized, and it presses against the wire train 20 which runs an ingot 30. With the wire 12 with bonded abrasive which constitutes the wire train 20, grinding of the contact section is carried out and, thereby, the ingot 30 pressed against the wire train 20 is cut by the wafer.

[0017] The cutting profile irregularity of a workpiece and the cutting conditions in the bonded abrasive wire saw which used the wire with bonded abrasive for below are explained. In order to improve cutting profile irregularity of a workpiece in the case of

cutting in a bonded abrasive wire saw, while lessening bending of the wire 12 with bonded abrasive under cutting shown in drawing 3 , it is effective to keep this amount of bending constant. The reason is that the wire 12 with bonded abrasive will become easy to move in a zigzag direction according to said amount of bending, wire spacing of the wire train 20 will be changed, and the wave of an one-sheet wafer [one sheet] cutting plane will increase if the amount of bending of the wire 12 with bonded abrasive under cutting is large. And it is equal to keeping constant small the value of the cutting resistance FZ (g/cm) of the direction of a right angle to the transit direction of the wire 12 with bonded abrasive shown in drawing 3 to keep constant the amount of bending of this wire 12 few. It is the large abrasive grains 2 and 2 of the wire 12 with bonded abrasive to cutting that the cutting resistance FZ which is the cause by which wafer cutting profile irregularity gets worse increases. -- It is because eccritic [of the cutting powder 5 of a between] is bad, so cutting capacity declines when cutting powder discharge capacity does not catch up.

[0018] Then, the result of having investigated the amount FN (micrometer) of external waviness of a wafer cutting plane when cutting conditions other than the degree of concentration C which is the grain ratio of a wire with bonded abrasive are fixed and only degree of concentration C changes ****** to drawing 4 and drawing 5 , and relation with the cutting resistance FZ (g/cm) is shown. Here, the workpiece used for cutting uses not the ingot 30 but prismatic form Si single crystal ingot (200mm per side) of a cylindrical shape as shown in drawing 2 or drawing 3 from the purpose which keeps constant the contact length of the wire 12 with bonded abrasive, and a workpiece. When cutting the cylinder-like ingot 30, it is good to control a wire travel speed or to control a cutting feed rate to make regularity the cutting workload per unit time amount. It is supposed that it is fixed. drawing 4 and the measurement conditions of drawing 5 -- a cutting feed rate -- 1 (mm/min) -- Wire tension : 35(N) maximum linear-velocity:1800 (m/min), bidirectional cycle-time:30 (sec), acceleration-and-deceleration time amount: -- a simple grain (5 (sec), working liquid:water + water solubility coolant 3%, and abrasive grain grain-size:mesh #600 No.) and diameter of wire strand: -- the wafer cutting plane in cutting on the conditions of 0.18 (mm) -- a wave -- an amount FN and the cutting resistance FZ are shown.

[0019] as being shown in drawing 4 -- a wafer cutting plane -- a wave -- an amount FN -- a wafer cutting plane -- a wave -- in order to hold down to below an amount allowed value, it turns out that what is necessary is just to set the degree of concentration C of a wire with bonded abrasive or less to 75. Moreover, as mentioned above, since degree of concentration C increases rapidly or more by 75, according to drawing 5 , the cutting resistance FZ can also be referred to as getting worse the amount FN of wafer cutting plane external waviness in connection with what the cutting resistance FZ increases.

Degree of concentration shows the rate, i.e., a grain ratio, that abrasive grains, such as a diamond and CBN, are contained in the abrasive grain layer containing a binder. The grain ratio defines 25% or 4.4 (ct/cm3) as degree of concentration 100 by the percent by volume (1ct=200mg). In addition, this degree of concentration C is good to consider as the value of 20-200 according to the quality of the material of a workpiece.

[0020] the wafer cutting plane which is a workpiece when degree of concentration of the bonded abrasive of a wire is made or less into 75 in a bonded abrasive wire saw -- a wave -- although it is as above-mentioned that an amount is settled within an allowed value, they are still the conventional cutting conditions -- the damaged layer of a wafer -- deep -- moreover, the large abrasive grain 2 of a wire with bonded abrasive and 2 -- the resistance at the time of cutting -- dedropping -- being easy -- a sake -- a wire with bonded abrasive -- the fault that a life is short occurs. Since the wire with bonded abrasive is generally expensive, it is an indispensable technical problem to prolong the life of a wire with bonded abrasive, in order to lower the manufacturing cost of a wafer. A damaged layer is in the condition that many brittle modes are contained in shaving marks, and since many micro cracks exist in a cutting plane when the shaving marks in this brittle mode occur, it is a layer which cannot be used as a wafer for semi-conductor generation. Conversely, in respect of good cutting processing, a micro crack is shallow, and shaving marks serve as ductility mode. Since the lap process in the back process for wafer surface finish will take great floor to floor time if the damaged layer of a wafer is deep, the floor to floor time and the conversion cost of a wafer increase.

[0021] What is necessary is just to reduce the amount of slitting of abrasive grain each to a wafer, in order to make this damaged layer shallow. It is required to reduce a cutting feed per revolution for that purpose, or to gather the travel speed of a wire. Although cutting processing efficiency will fall in a wire saw if a cutting feed rate is made late, the improvement in a wire travel speed is advantageous in respect of cutting efficiency. By carrying out cutting processing using the wire with bonded abrasive concerning this invention, improvement in the speed of the wire rate which was not able to be set up in respect of supply of working liquid can be attained by the conventional loose grain wire saw.

[0022] The result of having measured the relation between the wire travel speed V (m/min) and the processing deterioration layer depth D (micrometer) to drawing 6 is shown. Above wire travel-speed 1200 (m/min), the depth of a damaged layer is decreasing rapidly and becomes like 5 (micrometer) of the abbreviation one half at the 900 (m/min) time as shown in drawing 6 . In the conventional loose grain wire saw, since the abrasive grain is contained in working liquid and the abrasive grain in working liquid was cutting the ingot which is a workpiece, unless the abrasive grain in working liquid did not ride on the wire, but was fully drawn in the cutting part and spread, the saw mark

of a cutting plane became excessive and was not able to cut an ingot 30 finely. Therefore, 600 to 800 (m/min) extent of the maximum set point of the wire travel speed in a loose grain method was a limit. However, in a bonded abrasive wire saw, since [which carries out the lubrication of the cutting section] what is necessary is just to recognize extent existence, working liquid can raise the upper limit of a wire travel speed.
[0023] The wire travel speed V (m/min) is shown in drawing 7 , and relation with the cutting resistance FZ (gf/cm) is shown on an axis of abscissa. It is alike, therefore the cutting resistance FZ tends [which the wire travel speed V increases] to decrease as shown in drawing 7 . If the cutting resistance FZ decreases, the amount of external waviness of a wafer cutting plane will decrease, and a good wafer will be obtained.
[0024] Since the damaged layer of a cutting plane can be made thin, it becomes possible to ****** a good wafer cheaply and the large abrasive grain 2 and the amount of slitting in each of 2 -- decrease further according to such effectiveness while being able to improve the efficiency of cutting processing, it becomes possible for the large abrasive grain 2 and the probability for 2 -- to drop out to decrease, and to prolong the life of a wire with bonded abrasive.
[0025] Furthermore, since the large abrasive grain 2 and 2 -- which contribute to cutting have fixed by the fixing material 4 according to the gestalt of implementation of the processing approach of the wire with bonded abrasive concerning this invention, and a bonded abrasive wire saw, being held by the small abrasive grain 3 and 3 -- Only the fixing material 4 which is a Prior art compares with the large abrasive grain 2 and the approach of fixing 2 --, and they are the large abrasive grains 2 and 2. -- The fixing force is high and the large abrasive grain 2 and 2 -- are a pile to dedropping. Moreover, the large abrasive grain 2 contributed to cutting is set to a diamond or CBN, the small abrasive grain 3 is compared with a diamond or CBN, and it is far cheap SiC and aluminum 2O3. By carrying out, cutting capacity becomes possible [******(ing) a high wire with bonded abrasive cheaply]. Therefore, while being able to offer a cheap and long lasting wire with bonded abrasive, as said explanation, the wave of the cutting processing side of a wafer can be lessened, and as shown further below, reduction of cutting time amount and cutting cost can be aimed at.
[0026] The wire travel speed V (m/min) is taken along an axis of abscissa at drawing 8 , and the measurement result made into the wire life WL (mm2/m) at the axis of ordinate is shown. here -- the wire life WL -- unit wire die length -- (-- the cutting area (mm2) of the ingot currently cut without omission of the large abrasive grain 2 in per [m)] is shown. Therefore, it is shown that the life of a wire is so long that the value of the wire life floor line is large, and it is economical. According to drawing 8 , if it becomes more than wire travel-speed V=1200 (m/min), compared with the wire life in the condition of V= 900 (m/min), it will become large suddenly more than twice, and the value of the wire life

WL increases by gathering the wire travel speed V further.
[0027] in addition, as a means for raising a wire travel speed The groove roller 18 which is not illustrated and 18 -- Drive-motor and wire reel motor 26A, The high increase in power (torque, improvement in an engine speed) of 26B, and the groove roller 18 and 18 -- Modification of a drive reduction gear ratio, It corresponds combining a cure, such as reducing the load which reduces the amount of the groove roller 18 and the wire with bonded abrasive of 18 -- used for major-diameter-izing, lightweight-izing of wire reels 14A and 14B, and cutting, and is applied to the wire reel motors 26A and 26B.

[Translation done.]

* NOTICES *

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] The sectional view in which the wire 12 with bonded abrasive concerning this invention exaggerated the bonded abrasive wire 12, and showed the condition of cutting the ingot 30.
[Drawing 2] The wire path block diagram of a bonded abrasive wire saw.
[Drawing 3] Drawing showing the value of the cutting resistance FZ (g/cm) of the direction of a right angle to the transit direction of the wire 12 with bonded abrasive.
[Drawing 4] Drawing showing relation with the amount FN (micrometer) of external waviness of the wafer cutting plane when changing degree of concentration C to an axis of abscissa.
[Drawing 5] Drawing showing relation with the cutting resistance FZ (g/cm) when changing degree of concentration C to an axis of abscissa.
[Drawing 6] Drawing showing relation with damaged layer depth D (micrometer) when changing the wire travel speed V (m/min) to an axis of abscissa.
[Drawing 7] Drawing showing relation with the cutting resistance FZ (g/cm) when changing the wire travel speed V (m/min) to an axis of abscissa.
[Drawing 8] Drawing showing relation with the wire life WL (mm2/m) when changing the wire travel speed V (m/min) to an axis of abscissa.
[Description of Notations]
1 -- Wire strand
2 -- Large abrasive grain
3 -- Smallness abrasive grain
4 -- Fixing material
5 -- Cutting powder
7 -- Working liquid
10 -- Bonded abrasive wire saw

12 -- Wire with bonded abrasive
30 -- Ingot

[Translation done.]

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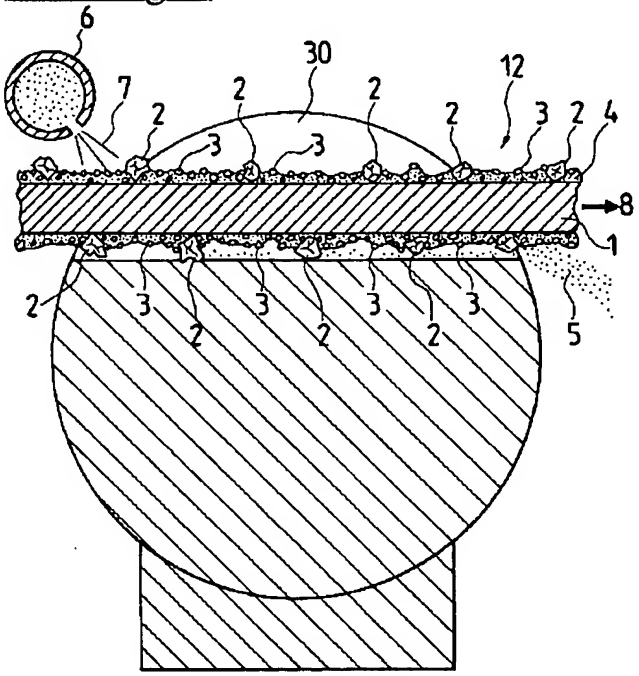
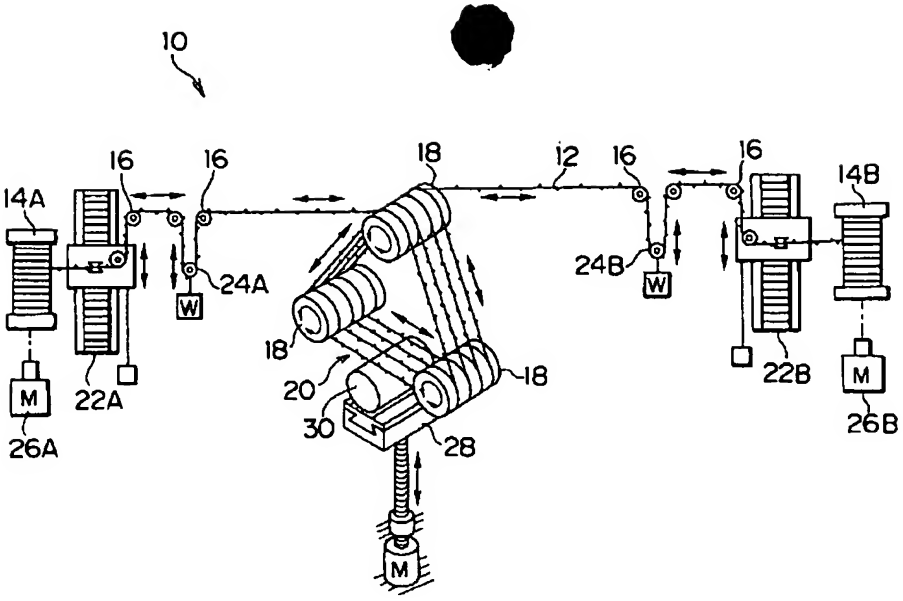
DRAWINGS

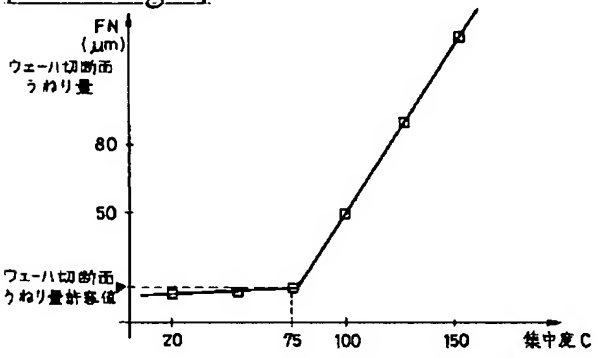
[Drawing 1]



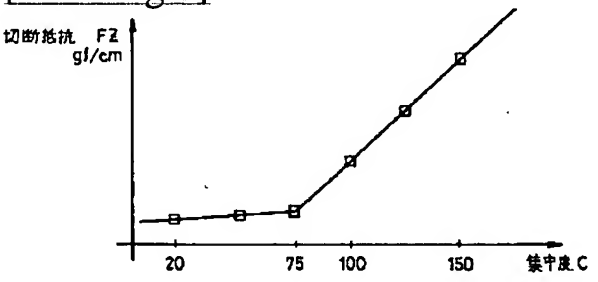
[Drawing 2]



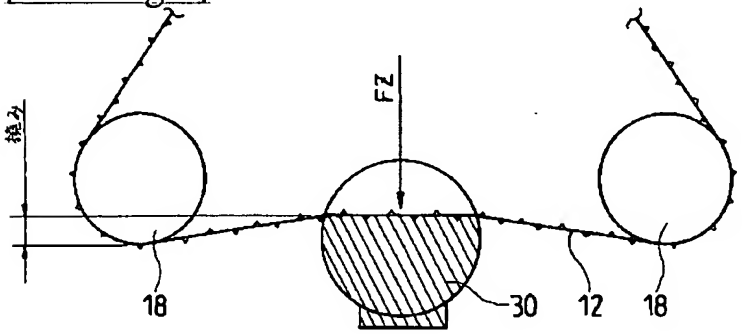
[Drawing 4]



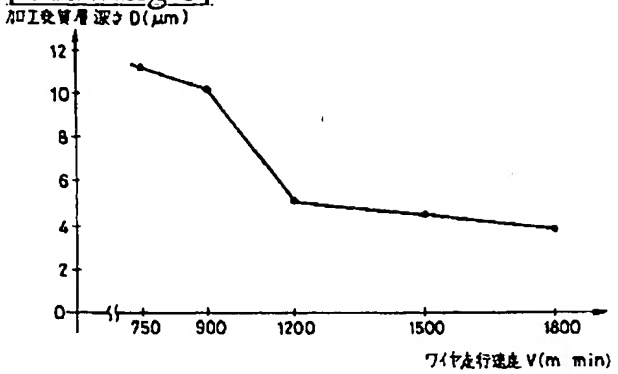
[Drawing 5]



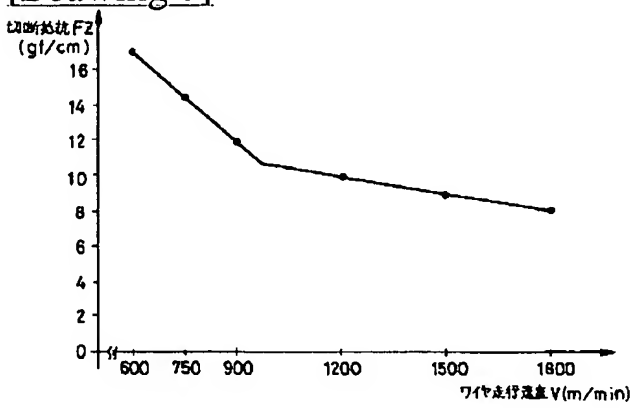
[Drawing 3]



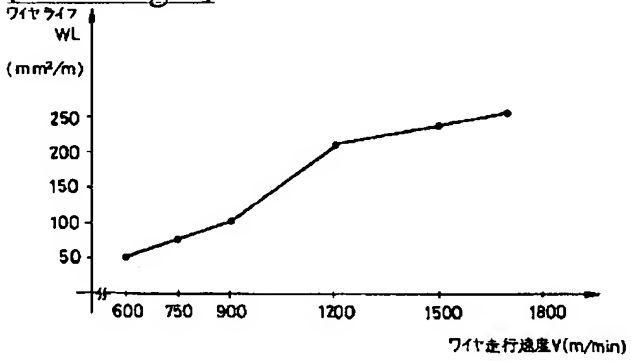
[Drawing 6]



[Drawing 7]



[Drawing 8]



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